Uncertainty in Simulations of Future Climate Conditions

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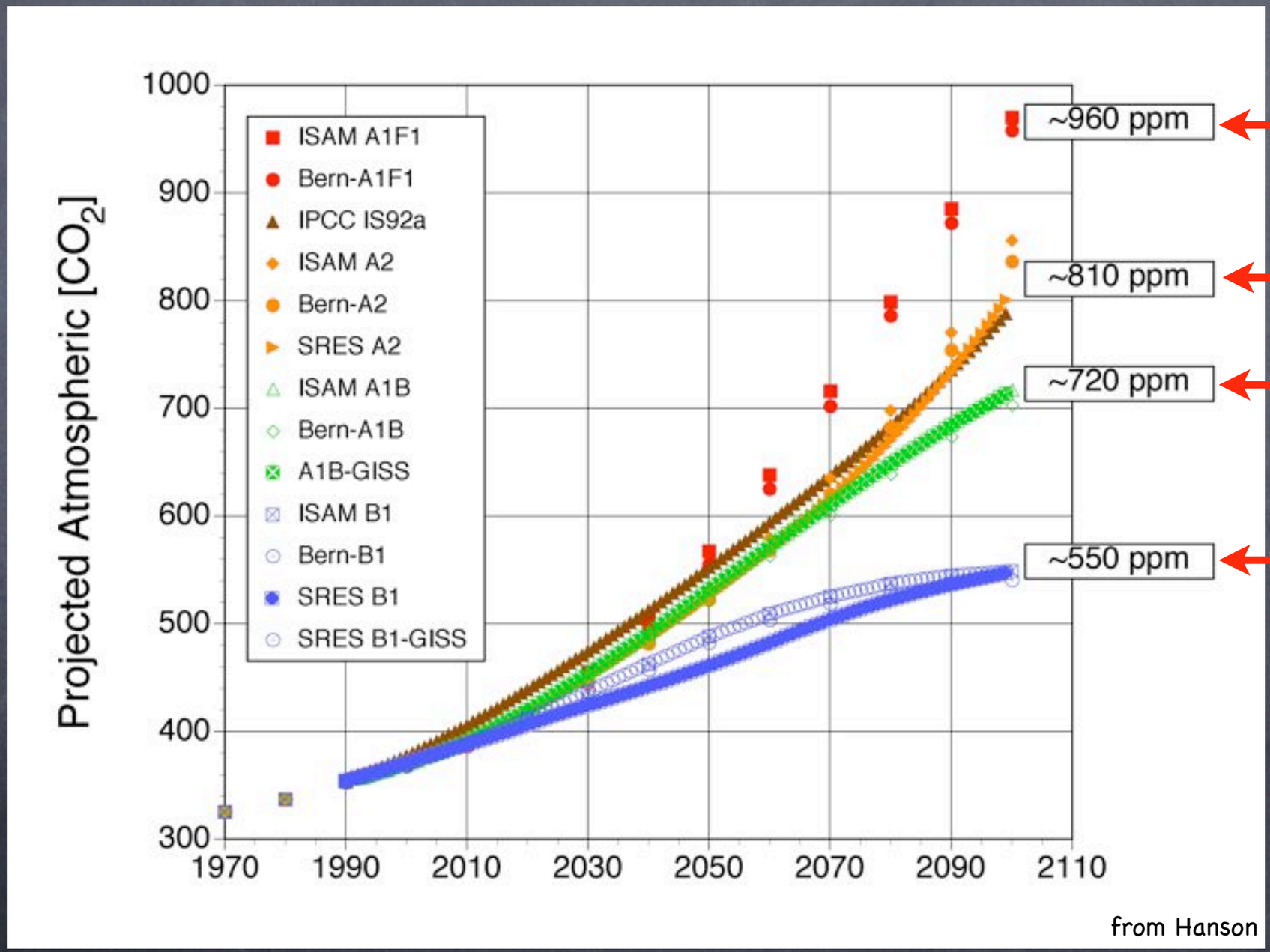
Outline

- The problem at hand
- Forcing uncertainty
- Model configuration uncertainty
- System predictability uncertainty
- Geographic uncertainty
- What do we need?

The Problem:

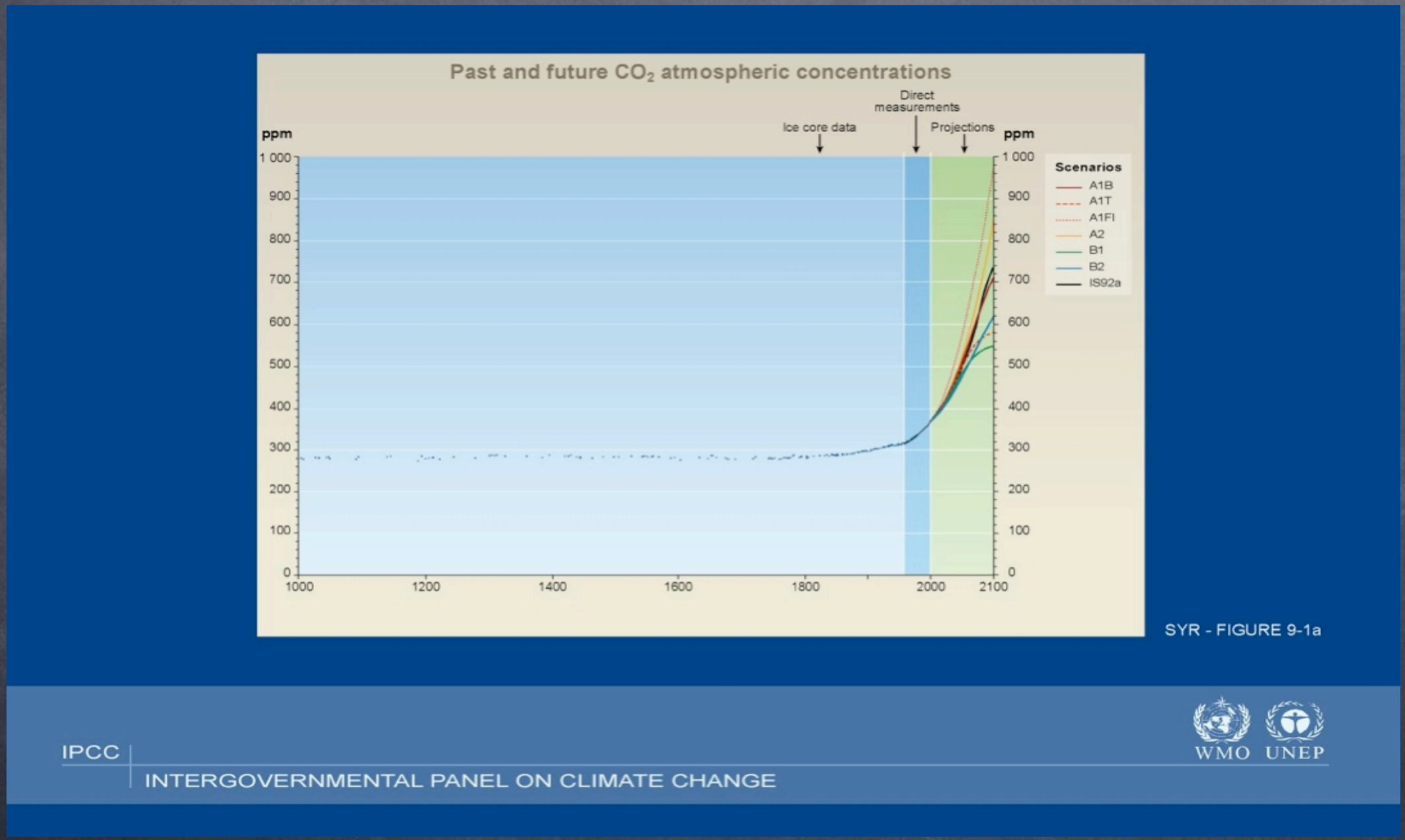
Characterize the relationship between atmospheric CO_2 concentration and climate with sufficient accuracy, breadth and certainty to enable the development of local, national and international policy.



from Hanson

The Problems with the Problem

1. We have about 50 years of high quality data for testing our models.
2. The data we have is not entirely representative of the system we want to understand.
3. Decisions will be made today based on simulations that won't be validated until 2050.



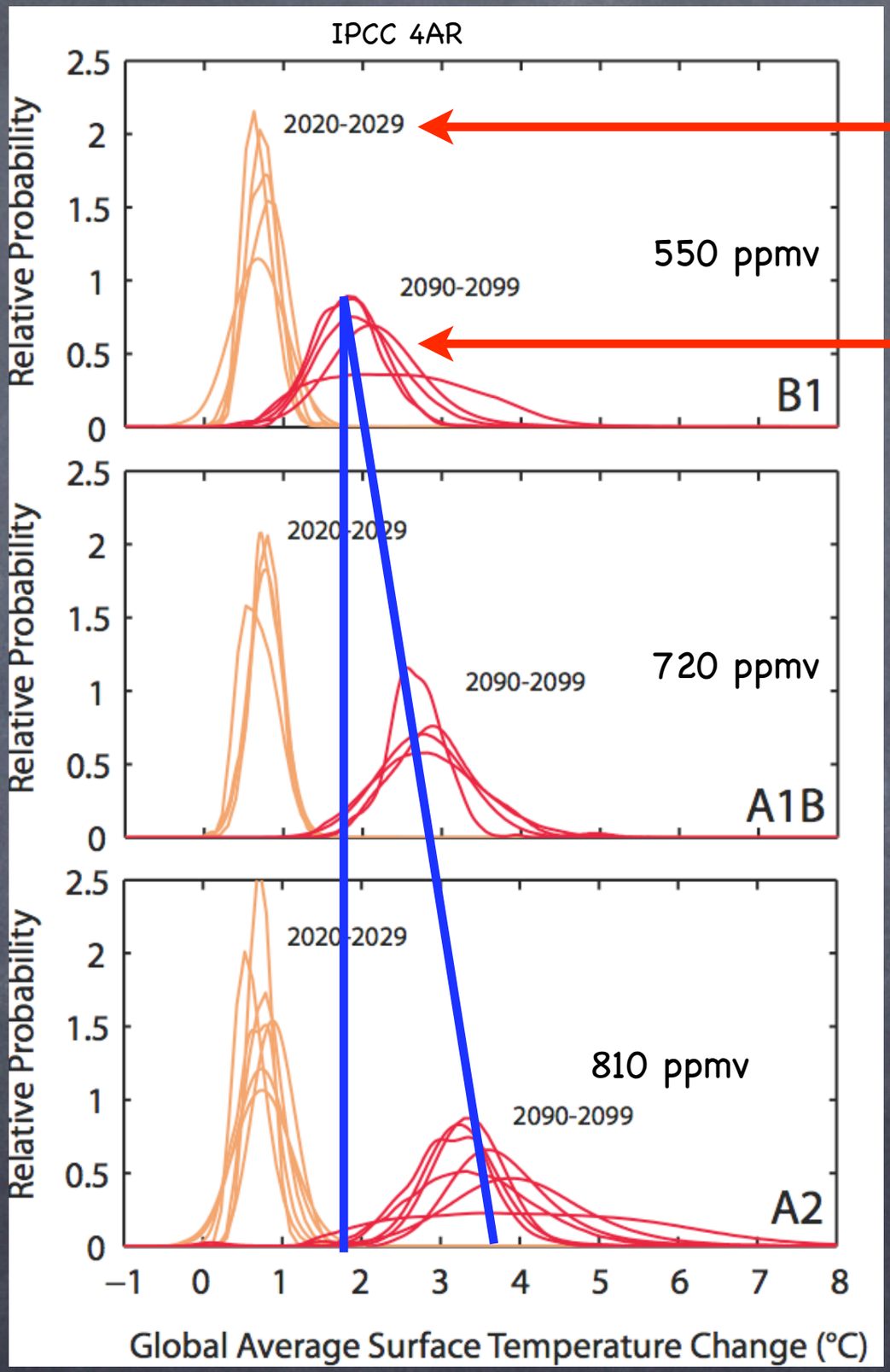
Forcing Uncertainty

Different lines provide estimate of inter-model uncertainty.

Different graphs provide estimate of inter-scenario uncertainty.

Estimates of global temperature rise are primarily determined by scenario choice, not by model choice.

Note that estimates of uncertainty are obtained by simply analyzing the "ensemble of opportunity."



Different time periods

Different model estimates

Model Configuration Uncertainty

(it's true, our models aren't perfect .... yet)

- Many system processes are not currently resolved in Earth Systems Models (ESMs). Parameterizations of one type or another will be a part of ESMs for decades to come. There is uncertainty associated with **model parameter choices**.

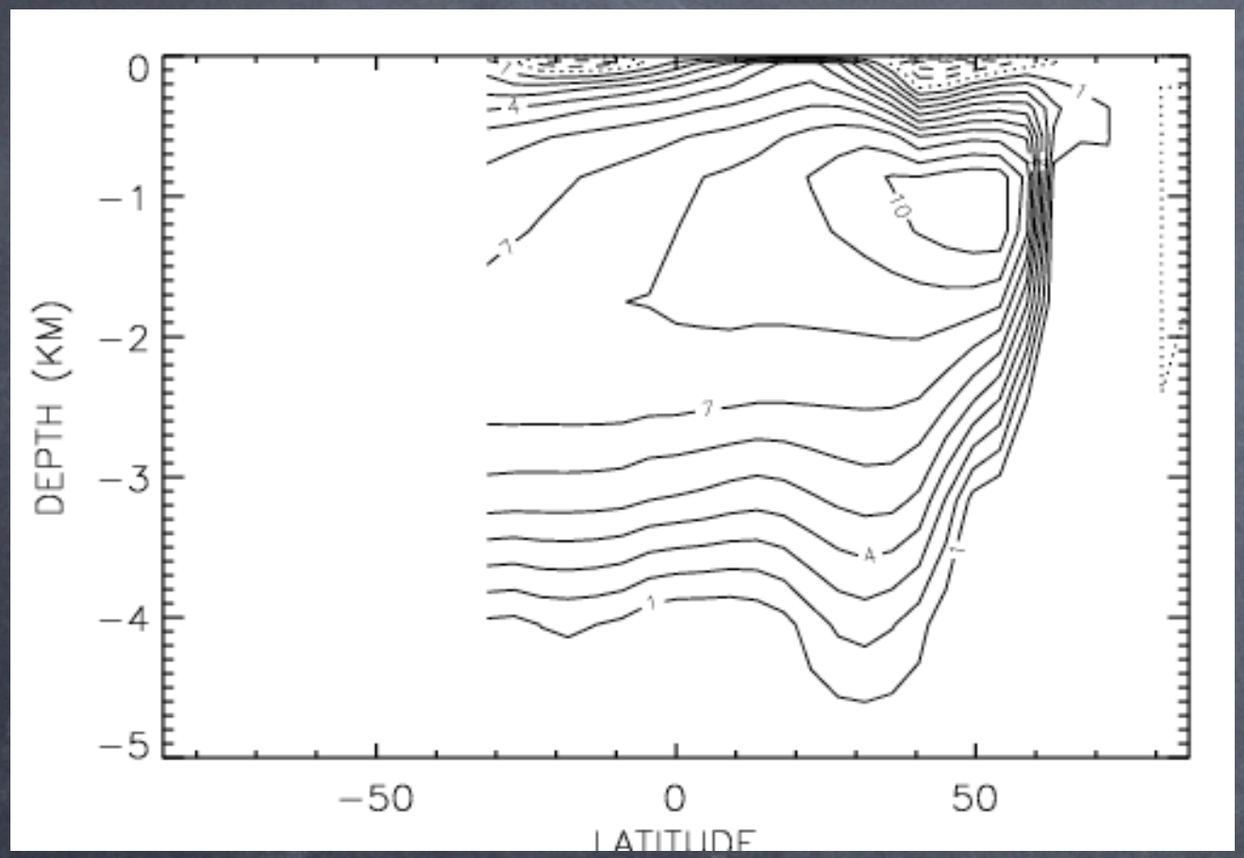
- ESMs are an incomplete description of the physical system. There is uncertainty associated with **processes that are neglected**.

- ESMs are tested on past climate (primarily the last 50 years), yet are expected to provide detailed information regarding the state of a (much different) future climate. There is uncertainty associated with the **amount and quality of "training data"** available to develop ESMs.

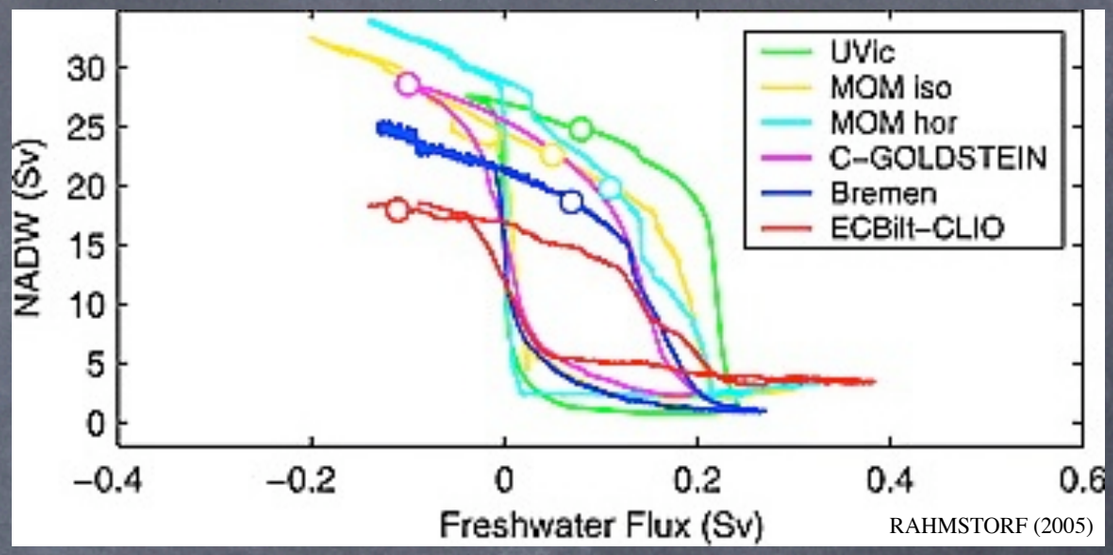
System Predictability Uncertainty

Even when the models are perfect, there is no guarantee that we will predict the correct trajectory!

Meridional Overturning Circulation (MOC) (brings warm water into North Atlantic)



The state (and strength) of the MOC is path-dependent.

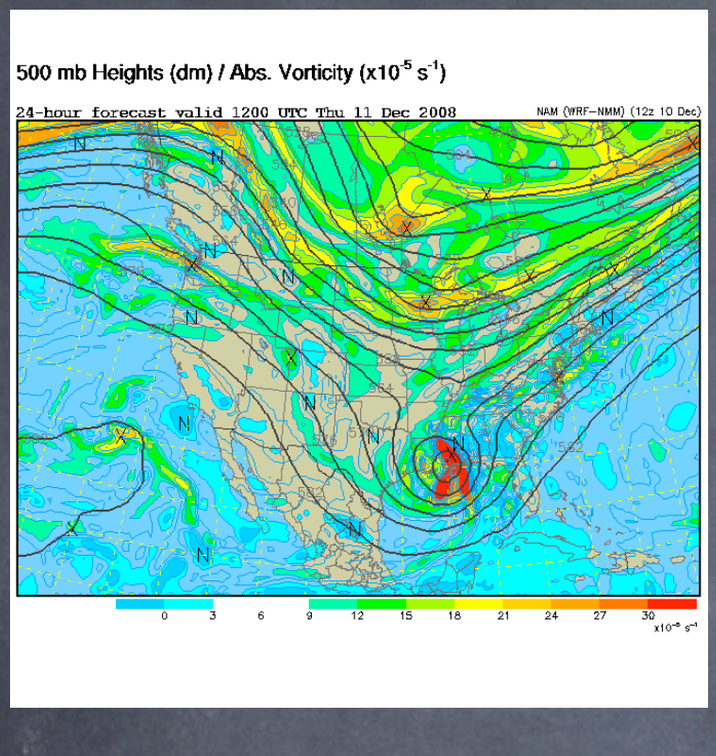


RAHMSTORF (2005)

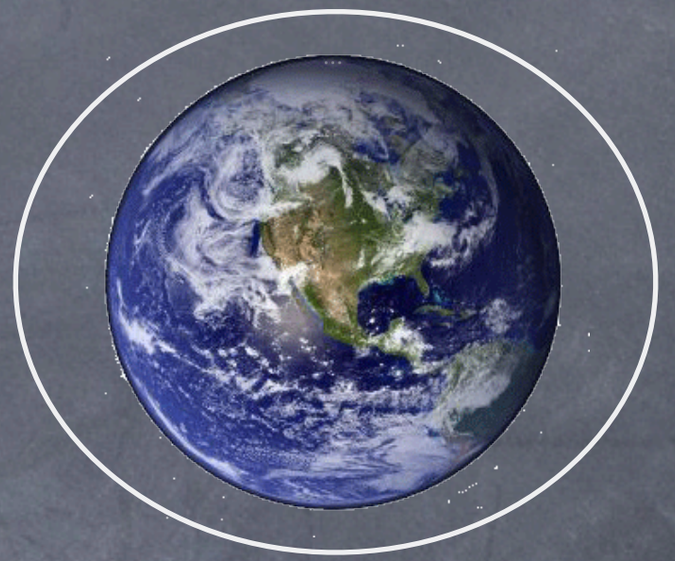
The MOC is double-valued, i.e. for the same precipitation there are two stable MOC conditions.

The system is chaotic. There is uncertainty related to the system sensitivity to initial conditions.

System Predictability Uncertainty



climate



Weather: Deterministic predictability limit of 14 days

Globally-average temperature: primarily at function of CO_2.

Most of the interesting (and relevant) phenomena occurs in the middle, fuzzy zone -- modified by CO2-concentration but with a strong chaotic component (e.g. El Nino).

Geographic Uncertainty

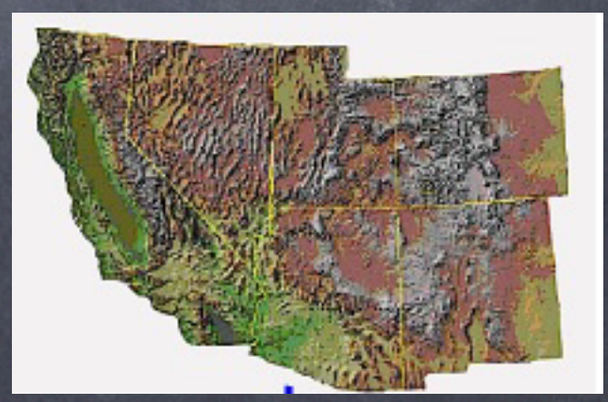
No one lives at globally-averaged temperature ....

For **adaptation** (i.e. accommodating a warming climate) policy-makers need detailed assessments of impacts at the scale of society's infrastructure.

For **mitigation** (i.e. reducing GHG emissions to avoid impacts) treaty-negotiators will desire detailed assessments of relative geographic risk due to rising emissions.

There is uncertainty associated with the geographical pattern of warming and (as importantly) the related changes in regional climate that will accompany the warming (e.g. changes in mean/variance in precipitation and abrupt events).

uncertainty



Summary

This is a coupled social-engineered-natural system.

Climate models have been used primarily to understand the least uncertain aspect of the problem: the relationship between atmospheric CO2 concentration and globally-averaged surface temperature.

The coupled system is, in many ways, dominated by uncertainty.

What do we need?

1. A rigorous framework for measuring each facet of uncertainty in this coupled social-engineered-natural system.

2. The ability to propagate uncertainty from one system component to the connected system components, e.g. from global forcing through regional impacts.